RESEARCH DEPARTMENT

A set of phosphors for use in a colour telerecording display

TECHNOLOGICAL REPORT No. PH-23

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THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

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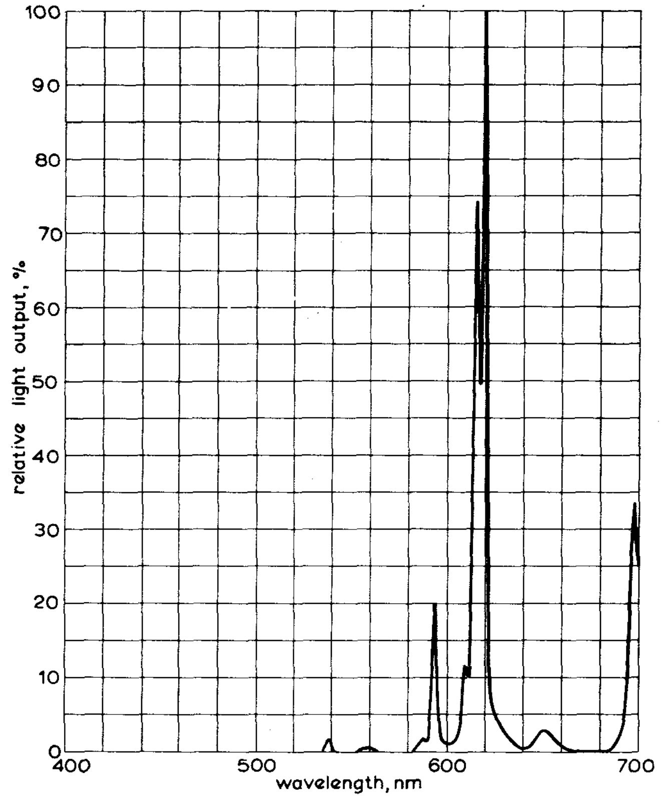

Fig. 1 - Spectral emission of red phosphor

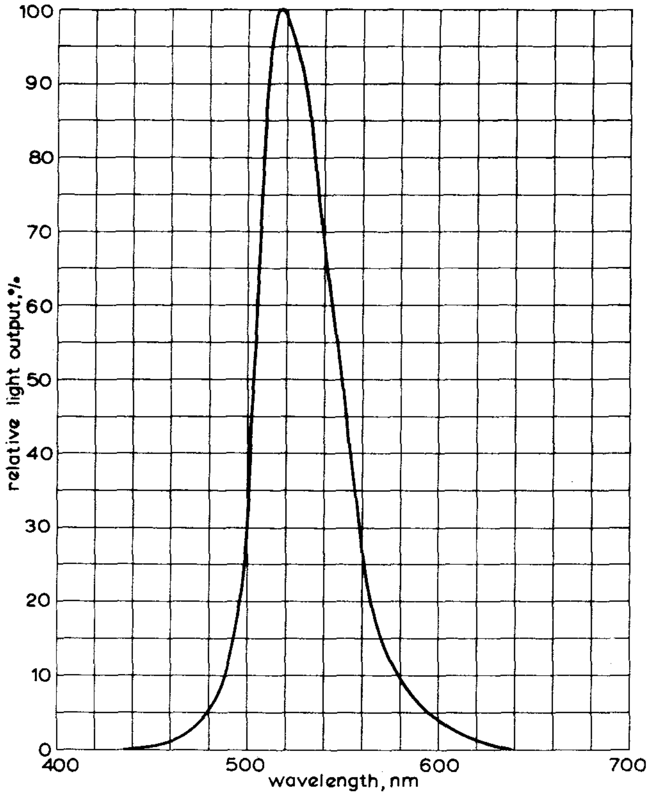

Fig. 2 - Spectral emission of green phosphor

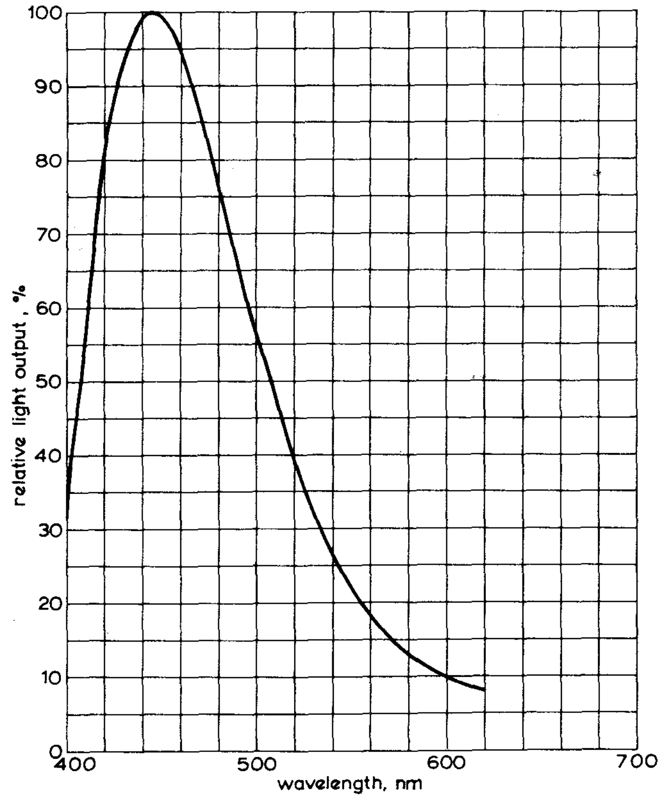

Fig. 3 - Spectral emission of blue phosphor

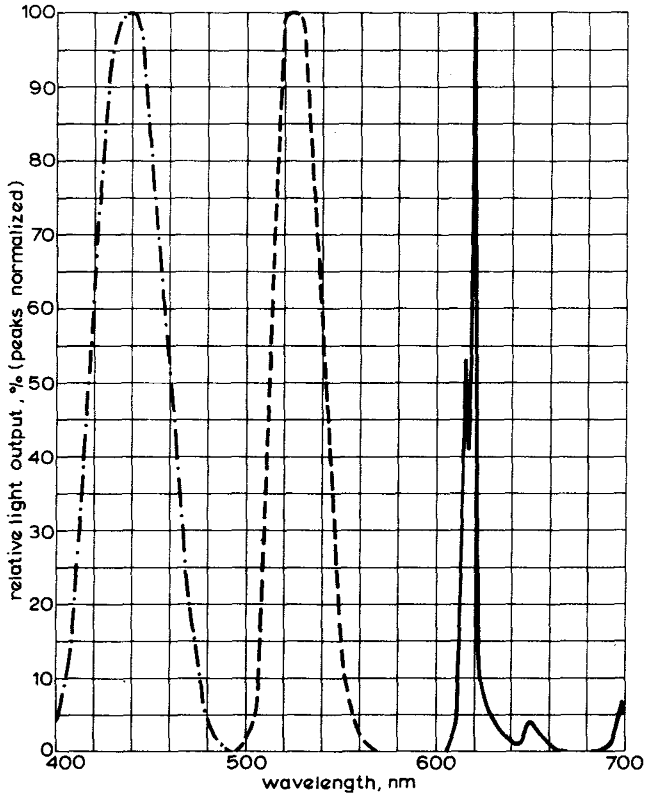

Fig. 4 - Spectral characteristics of the light from the three colour-separation channels

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SUMMARY

The spectral and actinic characteristics of three phosphors (red, green and blue) for use in a colour telerecording display are described. Absorption-type filters are specified for shaping their emission spectra.

1. INTRODUCTION

The factors influencing the choice of cathode-ray tube phosphors for use in a colour telerecording display have been discussed elsewhere.[1] In this previous discussion it was mentioned that the zinc-sulphide phosphor used in the blue colour-separation channel had a light output/beam current characteristic of insufficient linearity. A blue-emitting silicate phosphor has recently become available which does not suffer from this disadvantage. The spectral characteristics of this silicate phosphor are described in this present report and, for completeness, the characteristics of the red (yttrium vanadate) and green (willemite) phosphors described in reference 1 are restated; the actinic characteristics of the three phosphors are also compared.

2. SPECTRAL CHARACTERISTICS

The spectral characteristics of the red, green and blue phosphors are shown in Figures 1, 2 and 3 respectively. In the case of the red-emitting phosphor, the peak light-output occurs at approximately 620 nm; this is a somewhat shorter wavelength than that desirable for maximum film sensitivity (about 650 nm). The output at 700 nm is too long in wavelength to expose most emulsions; emission at wavelengths shorter than 610 nm must be removed by filtering to avoid exposing the magenta dye-forming layer. The spectrum of the green-emitting phosphor covers a range of 430 to 640 nm; restriction to a much narrower band is necessary to minimise unwanted exposure of the yellow and cyan dye-forming layers. As the blue-emitting phosphor emits some radiation at all wavelengths to which the film is sensitive, the unwanted exposure of both the cyan and the magenta dye-forming layers must be considered in the choice of a suitable shaping filter. Particular care is required to avoid exposure of the magenta dye-forming layer as this has significant sensitivity to light of short wavelengths (see Fig. 2 of reference 1).

Suitable absorption-type shaping filters for use with the three phosphors are specified in Table 1. The use of these filters in conjunction with dichroic combining mirrors (see Figs. 9 and 10 of reference 1) produces the spectra of light from the three colour-separation channels shown in Fig. 4.

TABLE 1

Absorption-type Shaping Filters

Channel	Phosphor	Wratten absorption filter type(s)
red	yttrium vanadate	29
green	willemite type D3	12 and 44
blue	silicate (development sample)	98

3. ACTINIC CHARACTERISTICS

The actinic intensities of the three radiations from the colour-separation channels of the telerecording display are considered to be equal when their combined effect results in the production of a neutral area on the final film-reproduction of the display (in other words achievement of equal equivalent neutral densities of the three layers). If a negative/positive film process is used it is assumed in this definition that no colour correction is made at the printing stage. Since the phosphors have linear light-output/beam-current characteristics, it is possible to express the intensity of the light emitted by each channel in terms of the cathode-ray tube beam current, assuming that other factors which influence the relationship between these two quantities remain constant. In practice it is convenient to measure the mean cathode currents which flow when a video waveform corresponding to white is supplied to the display equipment, since in the cases of the phosphors under discussion the magnitudes of these currents are large compared with those due to leakage paths within and around the cathode-ray tube. Table 2 shows the mean 'white' cathode currents required, using typical tubes, for the optimum exposure* of Eastman negative film stock type 5251 under the following conditions:-

Raster size: 120 mm x 90 mm
Number of fields exposed: 2 (i.e. one complete picture)
Cathode-ray tube face-plate: clear (92% transmission) + shaping filters
E.H.T.: 25 kV
Lens aperture: f/2·8

TABLE 2

Mean 'white' cathode currents for optimum exposure of 5251 negative film stock

Channel	Phosphor	Cathode current for white (μA)
red	yttrium vanadate	500
green	willemite type D3	170
blue	silicate (development sample)	90

It can be seen that for equal actinic intensities the red channel requires nearly three times the beam current of the green channel and this in turn requires nearly twice the beam current of the blue channel. This inequality in beam current values is due partially to differing phosphor efficiencies and shaping-filter losses, and also to the fact that the film stock is intended for use in artificial (tungsten) lighting and therefore has enhanced sensitivity to light of short wavelengths.

Satisfactory results have been obtained with white-light intensities of one-half the optimum values indicated above (for example, a satisfactory one-field exposure has been made using these cathode current values); furthermore, exposures made with the cathode current of the red tube reduced to two-thirds of the value shown in Table 2 (the green and blue tubes as listed in Table 2) have been adequately corrected at the printing stage of the film process.

It should be emphasized that the values given in Table 2 apply to a particular batch of film stock and to three particular cathode-ray tubes. In practice the appropriate values require determination for each batch of film stock and each individual cathode-ray tube; determination of the cathode current values should also be made at intervals on each cathode-ray tube to allow for phosphor-ageing effects.

4. CONCLUSIONS

Suitable phosphors for use in a colour telerecording display are:-

Red channel : yttrium vanadate
Green channel : willemite type D3
Blue channel : a silicate development sample (Ferranti)

Using suitable absorption-type shaping filters and dichroic light-combining mirrors, satisfactory exposure of each wanted dye-forming layer, together with exposure of the unwanted layers (see reference 1), can be obtained.

5. REFERENCE

1. The specification of colour sensitometric parameters in colour film telerecording, BBC Research Department Report No. T-182, Serial No. 1966/69.

6. ACKNOWLEDGEMENTS

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* exposure to achieve the same dye densities in white picture areas as would be obtained by correct exposure in normal usage.

JMP

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